

Contact

Francesca Santoro, Julian Barbieri
E-mail: f.santoro@unesco.org,
j.barbieri@unesco.org
Phone: +33 1 45683952



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INDICATORS FOR INTEGRATED COASTAL ZONE MANAGEMENT (ICZM) : *Methodological Factsheets in support of comparable measurements and an integrated assessment in coastal zones*

The **ICZM Protocol for the Mediterranean Sea** (the 'ICZM Protocol'), signed in Madrid on 21 January 2008 and ratified on 24 March 2011, represents a milestone for the implementation of ICZM in the Region and can serve as a blueprint for the implementation of ICZM in other Regional Seas. The **PEGASO project** builds on existing capacities and develops common approaches to support integrated policies for the Mediterranean and Black Sea Basins in ways that are consistent with the ICZM Protocol.

The PEGASO project has developed **a core set of indicators** that are instrumental in measuring the implementation of ICZM policies and programmes. The core set of ICZM indicators addresses the specific requirement of Article 27 of the protocol to '*define coastal management indicators*' and '*establish and maintain up-to-date assessments of the use and management of coastal zones*'. In doing so, the PEGASO project has widely built on previous and existing indicator sets developed by different institutions and projects, and which are duly acknowledged (see '[Methodological paper for the selection and application of PEGASO ICZM indicators](#)' for further reading and background material)

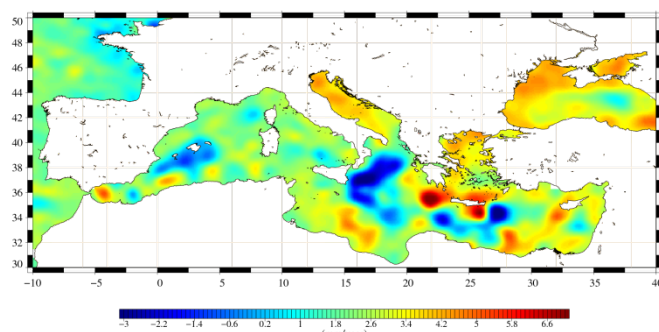
The present Methodological Factsheet is part of a set of 15 factsheets that are made available to end-users. This set of factsheets is conceived to support a harmonized approach to calculate ICZM indicators at different spatial scales in the Mediterranean and Black Sea regions.

Name of the Indicator	
Sea level rise and SLR relative to land	
Objective of the Indicator	
<p>The position and height of the sea relative to the land (relative sea level - RSL) determine the location of the shoreline. Although global fluctuations in sea level may result from the growth and melting of continental glaciers, thermal expansion of seawater and large-scale changes in the configuration of continental margins and ocean floors, there are many regional processes that result in rise or fall of RSL that may affect one coastline and not another. These include: changes in meltwater load, crustal rebound from glaciation, uplift or subsidence in coastal areas related to various tectonic processes (e.g. seismic disturbance and volcanic action), fluid withdrawal, and sediment deposition and compaction. RSL variations may also result from geodetic changes such as fluctuations in the angular velocity of the Earth or polar drift. Tide-gauge records suggest an average global sea-level rise over the last century of 0 to 3 mm per year, though there is no firm evidence of acceleration in these rates. Indeed, a recent study by the US Environmental Protection Agency predicts that global sea level is likely to rise 15cm by 2050 (about 3mm/year) as a result of human-induced climate warming¹.</p> <p>Many geomorphological changes in the marine and coastal zone are affected by fluctuations in relative sea level (RSL)². Changes in RSL may alter the position and morphology of coastlines, causing coastal flooding, water logging of soils and a loss or gain of land. They may also create or destroy coastal wetlands and salt marshes, inundate coastal settlements, and induce salt-water intrusion into aquifers, leading to salinisation of groundwater. Coastal ecosystems are bound to be affected, for example, by increased salt stress on plants. A changing RSL may also have profound effects on coastal structures and communities. Low-lying coastal and island states are particularly susceptible to sea-level rise. It is estimated that 70% of the world's sandy beaches are affected by coastal erosion induced by RSL rise. Variations in sea levels are natural responses or consequences of climate change, geoidal variations, movements of the sea floor and other earth processes outlined above. It has been suggested that human actions including drainage of wetlands, withdrawal of groundwater (which eventually flows to the sea) and deforestation (which reduces terrestrial water storage capacity), may currently contribute about 0.5mm/year to a global rise in sea level. Human-induced climate change is also of obvious importance. Local changes may be caused by large engineering works nearby, such as river channelling or dam construction, that influence sediment delivery and deposition in deltaic areas¹.</p>	
Policy context	
ICZM Policy Objective	To prevent damage to coastal environment, and appropriate restoration if damage already occurred
ICZM Protocol Article	Article 8: <i>Protection and sustainable use of the coastal zone</i>
	Article 22: <i>Natural hazards</i>
	Article 23: <i>Coastal erosion</i>
UNEP-MAP Ecological Objective	Objective 7: <i>Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.</i>
INSPIRE ANNEX I-III Data Theme (34)	Annex I, 8 Hydrography

¹ From the source: The US Global Challenge Research Information Office

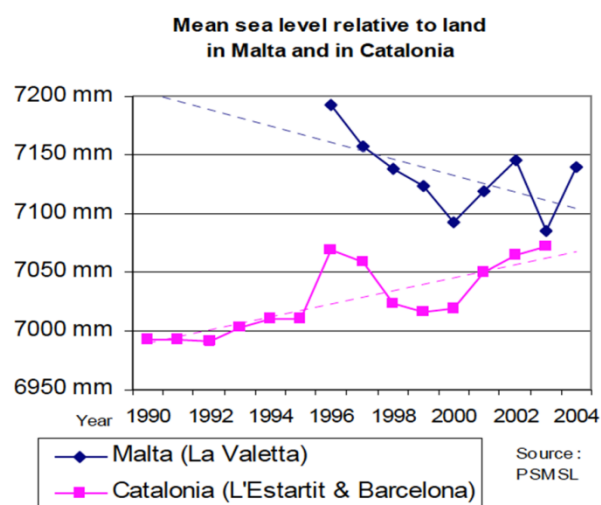
² The terms, sea level or mean sea level (MSL), refer to water level observations averaged over a time period (usually a month). Sea level is only a mean for a particular time period and it varies over longer time periods, on a monthly, inter-annual, and longer basis. This variation in sea level is measured relative to the land (to which the benchmarks are permanently attached). We therefore refer to this as relative sea level (the position and height of the sea relative to the land): if the land sinks (and the global sea level rises), it will appear that sea level is rising and, likewise, if the land rises (faster than global sea level rise) it will look like sea level is falling.

CALCULATION OF THE INDICATOR

Spatial consideration																	
Coverage	Resolution – Reporting Units																
Coastal zone of the reference region.	Individual tide gauges and coastal sampling stations																
Temporal consideration																	
Period	Resolution (time interval or unit)																
To characterise significant temporal variations, long-term series are necessary (30 years of data if possible).	Year, anual values																
Parameter(s)																	
(i)	Annual mean sea level relative to land (millimetres).																
Calculation method																	
Steps	Products																
1	From the PSML databank identify the existing tide gauges stations ³ in the reference region.																
2	Obtain the annual mean sea level relative to land of each existing tide gauge in the reference region for the last 30 years, if possible.																
	Raw data of the period of time to be analysed.																
	Regional MSL trends from Oct–1992 to Dec–2010																
																	
	<table><tr><td>No. of data</td><td>: 8484</td><td>St. Dev</td><td>: 1.2023</td><td>Skewness</td><td>: -0.81318</td><td>Minimum</td><td>: -5.28182</td></tr><tr><td>Mean</td><td>: 2.45680</td><td>Rms</td><td>: 2.76345</td><td>Kurtosis</td><td>: 3.74980</td><td>Maximum</td><td>: 9.45406</td></tr></table>	No. of data	: 8484	St. Dev	: 1.2023	Skewness	: -0.81318	Minimum	: -5.28182	Mean	: 2.45680	Rms	: 2.76345	Kurtosis	: 3.74980	Maximum	: 9.45406
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Mean	: 2.45680	Rms	: 2.76345	Kurtosis	: 3.74980	Maximum	: 9.45406										
	© CNES/LEGOS/CLS, 2011																
3	Calculate the mean annual value of the mean sea level relative to land by adding all the values of all the tide gauges for a given year, for the appropriate reference region or reporting unit, then take the average of the readings to obtain a result per year.																
	Annual mean values of the relative sea level (millimetres) for the period studied. (example in Graph 1: Catalonia. Source: DEDUCE).																
	Note: Aggregation is possible from the smallest spatial reporting units to national, European and worldwide levels. The trends from different stations may be used to produce an estimate of the sea level trend in a wider reference region. However, for larger scales it may be necessary to include regions along both west and east boundaries of each sea or ocean, for each wind																

³ To capture the spatial variability of the reference region, measurement points (tide gauges) must be well distributed along the coast, as far as possible.

regime, north and south of the equator to produce the best global average from the tide gauge records. The indicator could be disaggregated to the component impacts.



Current monitoring

Mean sea level data are obtained from tide gauge measurements. The Permanent Service for Mean Sea Level (PSMSL) is the global data base for long term sea level change information from tide gauges. The relative sea level data can be obtained from their web page <http://www.psmsl.org/>. In order to construct time series of sea level measurements at each station, the monthly and annual means have to be reduced to a common datum. This reduction is performed by the PSMSL using the tide gauge datum history provided by the supplying authority, forming the 'REVISED LOCAL REFERENCE' (or 'RLR') dataset.

Data Sources

For scientific purposes, the RLR dataset is preferred for the purpose of this indicator calculation rather than the METRIC, although the latter, which contains the total PSMSL data holdings, can also be analysed bearing in mind the datum continuity considerations. Without the provision of full benchmark datum history information, records will remain as 'Metric only' in the databank and not as RLR. It is a good general rule, therefore, that 'Metric' records should never be used for time series analysis or for the computation of secular trends. Without datum continuity their only use is in studies of the seasonal cycle of mean sea level. The RLR datum at each station is defined to be approximately 7000mm below mean sea level. This arbitrary choice was made many years ago in order to avoid negative numbers in the resulting RLR monthly and annual mean values. The detailed relationships at each site between RLR datum, benchmark heights, tide gauge zero, etc., are not normally required by analysts of the dataset, although they can be made available on request.

Assessment context

Use of the indicator in previous assessments/initiatives	Mediterranean Strategy for Sustainable Development (MSSD) coastal indicators The changing faces of Europe's coastal areas- European Environment Agency EEA (2006) SAIL Schéma d'Aménagement Intégrée du Litoral (2006) DEDUCE Développement durable des Côtes Européennes (2007)
DPSIR framework	Pressure
Link to anthropogenic pressure	CO ₂ emissions
Sustainability target or threshold	
Link with other assessment tools	Tools and methods for assessing risks and hazards in the coastal zones.
Example of integrated assessment	UNEP-MAP plan Bleu : State of the environment and development in the Mediterranean 2009

Scope for future improvements

To interpret the data in an assessment context of real coastal sensitivity, this information has to be analysed in conjunction with coastal characteristics and environmental hazards and risks, since the same change in sea level acting on areas of different geomorphic characteristics will induce responses of different magnitude.

Data Harmonization

In order to build a common, regional view for a particular indicator, it is crucial to harmonize the data in terms of e.g. concepts, definitions, reporting units, colour codes, value class boundaries and scoring methods. For this purpose, the PEGASO consortium has developed 'Guidelines for Data Harmonization' which are available from the 'Products' section on the PEGASO project website www.pegasoproject.eu. Although agreements may exist related to the presentation of certain indicators that are legally embedded, this may be less evident for indicators which are not (yet) used as an instrument within a policy context or within a region where the policy is not applicable. The PEGASO consortium encourages contributing partners, stakeholders and end-users to consult the 'Guidelines for Data Harmonization' document, and to actively engage in this process.

Indicator references (i.e. UNEP, EEA, ...)

The Permanent Service for Mean Sea Level : www.psmsl.org

MEDGLOSS : <http://medgloss.ocean.org.il/>

<http://www.aviso.oceanobs.com/en/news/idm/2001/mar-2001-mean-rise-in-sea-level-is-only-part-of-the-story/index.html> (refers to satellite data of SL, not RSL)

EEA CLIM 012: <http://www.eea.europa.eu/data-and-maps/indicators/sea-level-rise/>

DEDUCE : http://www.deduce.eu/SIF/SIF_25.2_final.pdf

Spatial Data Infrastructure for ICZM in the South-East Baltic : <http://corpi.ku.lt/SDI-4-SEB/state/25.pdf>